United States District Court
Northern District of Texas
Dallas Division

Vicki Timpa, et al Plaintiff, v. Dustin Dillard, et al, Defendants.	No. 3:16-CV-03089-N

EXPERT REPORT OF MARK KROLL, PhD, FACC, FHRS, FIEEE, FAIMBE

This report summarizes my analysis and findings and includes a statement of my opinions. The report also includes data and other information considered by me in forming my opinions and sets out my qualifications (including my CV which is an integral part of this report).

Mark Kroll, PhD, FACC, FHRS, FAIMBE 1 Nov 2019

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Brief Summary of Qualifications

I am a Biomedical scientist with a subspecialty in arrest-related-death.[1] My early career was focused on researching and developing electrical devices to diagnose and treat disease. Because of this work, on the effect of electrical shocks on the human body, I became heavily involved with handheld electrical weapons in 2003. That led to research in the related Biomedical issue of prone restraint.

Biomedical Science analyzes the human body as a physics problem. The largest areas are Bioelectricity (e.g. effects of shocks and stimulation) and Biomechanics (e.g. strength of bones and ribs).

My work as a biomedical scientist involves researching, lecturing, and publishing including lectures throughout Europe, South America, and Asia (in over 35 countries) as well as at many of the major universities and medical centers of the United States. Usually, the typical audience member is a cardiologist, medical examiner, or forensic pathologist. With over 380 issued U. S. patents and numerous pending and international patents, I currently hold the most patents on implantable medical devices of anyone in the world. Over 1 million people have had devices with some of these patented features in their chest, monitoring every heartbeat. http://bme.umn.edu/people/adjunct/kroll.html.

In 2010 was awarded the Career Achievement Award by the Engineering in Medicine and Biology Society (EMBS) is the most prestigious award given internationally in Biomedical Engineering.
http://tc-therapeutic-systems.embs.org/whatsnew/index.html

Believed to be the only individual to receive the high "Fellow" honor from both Cardiology and Biomedical societies. To wit:

1997 Fellow, American College of Cardiology
2009 Fellow, Heart Rhythm Society
2011 Fellow, IEEE Engineering in Medicine and Biology Society
2013 Fellow, American Institute for Medical and Biological Engineering

Author of over 200 abstracts, papers, and book chapters and also the co-editor of 4 books.

Relevant paper publications include over 80 papers, books, book chapters, and indexed letters on CEWs and arrest-related death (ARD) as well as numerous scientific meeting abstracts.[1-84] For more details please see CV at:
https://www.dropbox.com/sh/wju0hu6q3ca62xx/AAAlzTlLbKbxu5m34AsMfCrYa?dl=0

[1]See current CV for further details and specifics. My curriculum vitae containing details of my relevant formal education, experience, and publications authored is attached and made an integral part of this report.

There have also been many presentations on ARD to scientific, medical, pathology, as well as law enforcement, audiences. These include: 2007 American Academy of Forensic Science (AAFS) conference major presentation in San Antonio, Texas[75] and the 2007 BEMS (Bio-electromagnetic Society) meeting Plenary Address in Kanazawa, Japan.[77]

1. Major invited lecture at the 2006 NAME (National Association of Medical Examiners) conference in San Antonio, Texas.[85]
2. Advanced Death Investigation Course of St. Louis University (2007) as faculty lecturer to full audience.[86]
3. Faculty lecturer to full audience at Institute for the Prevention of In-Custody Death Conferences (2006 and 2007), Las Vegas, Nevada.
4. Oral presentation at the 2014 NAME (National Association of Medical Examiners) conference in Portland, Oregon.

In addition to the major addresses above, there have been lectures and presentations at the U.S. Department of Justice (2007), AAFS (2006), and BEMS (2006). As a direct outgrowth of my ARD research, I have written or edited several publications on the topic of excited (agitated) delirium.[62,73,87-89]

Relevant Committees and Boards:

1. American Society for Testing and Materials) ASTM, Committee: E54 Homeland Security Applications, Subcommittee: E54.08 Operational Equipment, including Less-Lethal Task Group, including: ASTM (draft) Standard WK61808 New Test Method for Correct Performance of Less-Lethal Electroshock Weapons Used by Law Enforcement and Corrections.
2. International Electrotechnical Commission (IEC) (Geneva, Switzerland) TC64 MT4 Committee. This committee is the top international authority for setting the international electrical safety limits for electrocution and other electrical dangers.
3. Axon Enterprise, Inc. (Axon né TASER), corporate and also Scientific and Medical Advisory Board.
4. ANSI (American National Standards Institute) standards committee on electrical weapons.

Courtroom testimony in U.S., Australia, and Canada, and retained expert in the United Kingdom. I have significant research, publications, and testimony in the areas of resuscitation, ARDs (arrest-related death), prone restraint, and biomechanics.

A Brief Primer on Arrest-Related Asphyxia Theories

Compression Asphyxia

Compression (aka mechanical) asphyxia is a real phenomenon and it has resulted in many deaths. This is not controversial. What is controversial and largely debunked now, is the misapplication of this to arrest-related and custodial deaths. In the USA alone there are about 800 cases of arrest-related-death annually and in some cases the subject expired after law enforcement officers used controlling pressure on the back of the chest during and after handcuffing.[90] Hence, there has been debate about the potential for law enforcement officers to be able to cause fatal compression asphyxia with their body weights.[91-101] This is sometimes incorrectly referred to as "restraint" or "positional" asphyxia due to the restraints of the wrists and ankles along with the prone position in the law-enforcement scenario.

Compression or crush asphyxia has caused death from soft-drink (soda) vending machine tipping, building collapse, vehicle accidents, crowd collapse, and trench cave-ins.[102-112] True compression asphyxia, has been differentiated as "a form of suffocation where respiration is prevented by external pressure on the body."[105,113]

Published research has found no evidence of compression asphyxia in hogtied individuals with a static mass up to 102 kg (225 lbs) on the back.[114] However, numerous deaths from falling soda machines have been reported. [106-109]

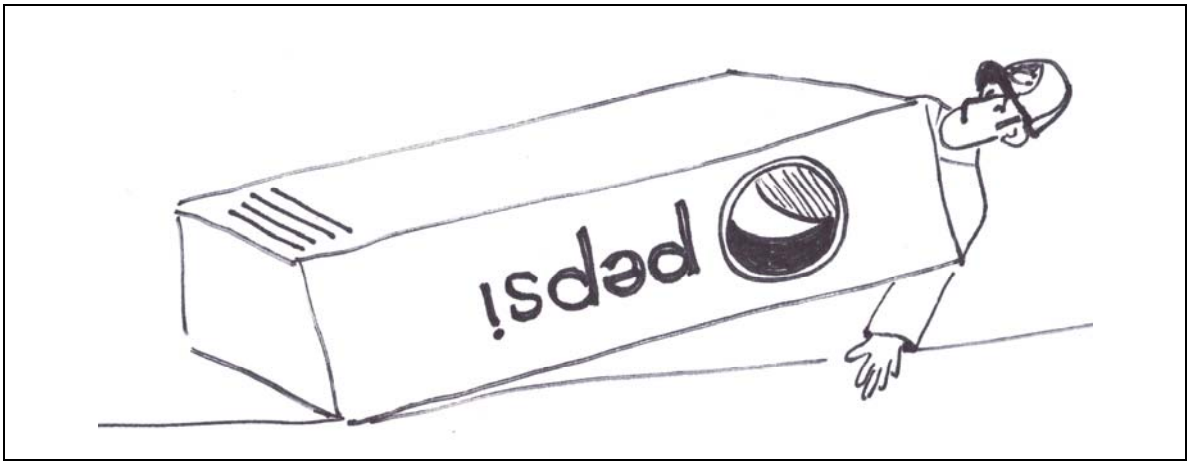


Figure 1. True compression deaths typically involve broken ribs and weights > 1000 lb.

Since a fully-loaded soda vending machine weighs up to 500 kg (1100 lbs), with most of the mass in the top, these deaths establish that an impact (falling) load of 500 kg can kill an adult human.

Most of the published fatal chest compression cases involve the mass of a car or tractor (typically > 1000 kg) compressing the torso and hence they set a high upper bound on the mass required for ribcage failure. [105 115] Conversely, cases of survival under a motor vehicle do not appear to have the full vehicle weight on the subject. For example, Shamblin reported a case of a farmer pinned under the steering wheel of an overturned tractor; he had several rib fractures but only on the right side and survived. [102]

Figure 2. The human chest can handle a surprising amount of weight.

A biomechanical ribcage model predicts that an adult male requires at least 572 ± 57 lbs of static chest mass to cause flail chest, a potentially lethal condition and a true compression fatality. Historical records exist of judicial "pressing" or the application of chest mass for interrogation or execution.[116] These records of judicial pressing show that about 600 lb is required to kill.

The concept of compression asphyxia as a cause of arrest-related or custodial deaths has been thoroughly debunked in the peer review literature.[96,99,100]

Figure 3. Volunteer in prone restrained position connected to spirometer.[114]

Prone and Positional Asphyxia

Similarly, people have died from positional asphyxia. Perhaps the most common form of this is people trapped upside down in a car for long period of time.[112,117] This concept also has been carried over and misapplied in an attempt to blame the prone position for arrest-related or custodial deaths.[93]

In fact, there have been 2 very large studies covering 1000s of forceful arrests that have shown no increased risk with prone restraint.[118,119] In fact, researchers are now arguing that the prone position is *preferred* as it leads to increased control and decreased subject and officer injury risks. See Figure 3 in which a volunteer is restrained in a prone position while breathing thru spirometry instrumentation. There is no clinically significant reduction in breathing capability.[114]

Parkes studied breathing by seated individuals forced to lean forward.[120] See Figure 4. The only clinically significant respiratory reduction seen with this restraint was with obese subjects as their abdominal mass interfered with diaphragmatic breathing.

Figure 4. A seated position with subject forced to lean forward can interfere with breathing — but only with an obese individual (not shown here).[120]

Restraint Asphyxia

Restraint asphyxia is another speculative theory to explain arrest-related or custodial deaths. This has also been thoroughly debunked.[118,119,121-126] Impressive experiments have been done in which volunteers were: (1) prone, (2) hog-tied, and (3) compressed with up to 225 pounds on the back.[114] See Figure 5.

The scientific literature on restraint has been nicely summarized by Barnett.[127] He reported:

> The reduction in spirometry measures was proportional to the extent of the restriction imposed by position, increasing weight applied on the torso and increasing obesity in the seated flexed position. The literature did not report that the reductions seen were clinically significant except for Parkes et al. who reported the reductions seen in the flexed seated position with obese individuals were operationally significant.

In other words, the only clinically significant respiratory reduction seen in restraint is with obese individuals forced into a seated position (and forced to lean forward) as their abdominal mass can interfere with diaphragmatic breathing.[120]

Figure 5. Maximally restrained prone subjects with 225 lb on the back have sufficient ventilation.[128]

Junk Science Under Different Names:

There are 3 intuitively appealing and often accepted theories for arrest-related and custodial deaths that are simply not supported by the peer-reviewed scientific literature. These are: compression asphyxia, restraint asphyxia, and positional (prone) asphyxia. They are basically 3 flavors of the same fundamental theory and they are all unsupported.[118,119,121-126]

Some continue to preach the anachronistic myth that prone positioning interferes with breathing. No matter how many studies have refuted this, it continues to be brought up. Of course, experts that raise this issue, do so without citations to the scientific literature since the literature does not support this old hypothesis.

In 2015, my colleagues and I authored the following summary of the situation in a lengthy review letter:[129]

In 2007, Michaelwitz investigated the ventilatory and metabolic demands in healthy adults who had been placed in the prone maximal restraint position (PMRP).[114] Maximal voluntary ventilation (MVV) was measured in seated subjects (n=30), in the PMRP (hogtied), and when prone with up to 90.1 or 102.3 kg of weight on their backs. MVV with >100 kg on their backs was 70% of the seated MVV (122±28 and 156±38 L/min, respectively; p<.001).

In 2012, Hall published her epidemiological study "Incidence and outcome of prone positioning following police use of force."[130] In her study, data from a single police force serving >1.1 million people were collected for 3 consecutive years. Officers prospectively documented the final position of the subject, among other data points, via electronic study forms embedded in standard force reporting forms. Final resting position was available for 1255/ 1269 subjects. Force was required in 1269 cases. The majority (52%) were not even left in a prone position. There was 1 death, and that occurred in a prisoner not in the prone position. The authors concluded "prone positioning was common and was not associated with death in our cohort of consecutive subjects following police use of force." In 2015, Hall published her further study reporting 4828 consecutive force events in seven police agencies in four cities, concluding that their data support the human laboratory data that the prone position has no clinically significant effects on subject physiology.[119]

In 2013, Savaser's group evaluated the effect of maximal prone restraint (PMPR) on a group aged 22–42 years old.[125] Each volunteer was hogtied and tested in five different positions: supine, prone, prone maximal restraint with no weight force, prone maximal restraint with 50 lbs added to the subject's back, and prone maximal restraint with 100 lbs added to the subject's back for three minutes. Heart rate (HR), blood pressure (BP) and oxygenation saturation (O2 sat) were monitored for each volunteer in each position. In addition, echocardiography was performed to measure left ventricular outflow tract diameter. HR, MAP or O2 sat were statistically no different in any of the positions.

In 2014, Sloane extended the work even further measuring the ventilatory and cardiovascular parameters in 10 intensely exercising volunteers (85% of their measured VO2 max) who were placed in PMPR after exercising and then studied while in three different positions for 15 minutes: (1) seated with hands behind the back, (2) prone with arms to the sides, and (3) PMPR position.[122] Cardiovascular parameters (oxygenation, stroke volume, inferior vena cava diameter, cardiac output, cardiac index, oxygenation, stroke volume, IVC diameter, cardiac output and cardiac index) were all measured. There was no evidence of hypoxia or hypoventilation during any of the monitored 15-minute position periods. Numerous other papers confirm the findings summated above.

In 2016, Karch published a review article on arrest-related-death which included the following relevant points, here paraphrased:[131]

1. "Positional asphyxia" or "restraint asphyxia," the theories most frequently proposed, are terms often used synonymously. The term "restraint asphyxia" came into use when the notion of "positional asphyxia" fell from favor (it was retracted in court testimony by its author, Reay) and was replaced with the phrase "restraint asphyxia," which is used in exactly the same way, and should be considered to have the same meaning.
2. Those who accept the theory of "positional or restraint asphyxia" assume that prone positioning is clearly harmful, even though all of the available peer-reviewed evidence suggests that quite the opposite is the case.
3. Attempts at introducing the newly defined "positional asphyxia" into the court system have been rejected by several United States courts. In Garcia v City and County of San Francisco (State of California, Superior Court, Case #984e221), the

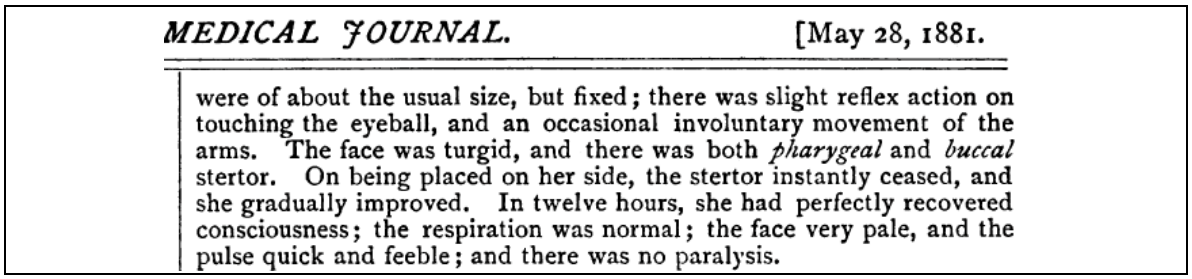
presiding judge ruled that "reliance by plaintiffs on the theory of positional asphyxia is irrelevant … the original proponent of the theory, Dr. Donald Reay, has now retracted it … Indeed, even Dr. Reay himself acknowledges the 1997 UCSD (University of California, San Diego) study refutes his earlier work. Everyone now agrees that there is no scientific evidence to support the idea that hog-tying or any other body position plays any role in causing life-threatening respiratory effects."

4. Positional asphyxia, as the term is used in court today, is an interesting hypothesis unsupported by any experimental data.

MRI studies of healthy volunteers show *lung perfusion is significantly greater in the prone position* than when studied in volunteers lying supine.[132] Ross and Hazlett conducted a prospective study examining 1085 violent arrests occurring over a 1-year period in 17 different police jurisdictions across the United States.[118] Police placed all of the arrestees in the prone position for 1-5 minutes; forcible measures were used to get them prone in 71% of cases. Handcuffs were used in 96% of the incidents and were first applied when the arrestee was prone in a ¼ of the cases. Hobble restraints were used in about ¼ of the cases. No deaths were recorded during the study and only 1 fracture occurred. The authors concluded "the use of prone position with violent arrestees is a safe restraint method."

Left Lateral Decubitus Position and the "Recovery" Myth

The Left Lateral Decubitus (LLD) position has been long-taught in basic life-support courses for an unconscious but breathing patient. The history of this technique is interesting. British physician Robert Bowles consulted on a 67-year old female unconscious stroke patient and her pupils…



MEDICAL JOURNAL. [May 28, 1881.

were of about the usual size, but fixed; there was slight reflex action on touching the eyeball, and an occasional involuntary movement of the arms. The face was turgid, and there was both *pharygeal* and *buccal* stertor. On being placed on her side, the stertor instantly ceased, and she gradually improved. In twelve hours, she had perfectly recovered consciousness; the respiration was normal; the face very pale, and the pulse quick and feeble; and there was no paralysis.

Figure 6. Bowles article extract on curing stroke with LLD position.

After Bowles published this in 1881, it caught on but has received minimal scientific research support.[133,134] A proposed benefit of the LLD position is that a patient will be less likely to aspirate possible vomit. A recent study has suggested that the LLD position be dropped since it makes it harder to monitor breathing and this delays resuscitation.[135]

"Left Lateral Decubitus" is a mouthful so the simple term "recovery" position was chosen for training. This unfortunately led some to believe that there is some sort of *recovery* occurring during this positioning. There is not. The position reduces the risk of airway blockage from vomiting. There is no evidence that ventilation is improved vs a prone or supine position. In fact, pulmonary function tends to be compromised with the LLD.[136,137] Hemodynamic function may also be compromised in those with heart failure.[138]

The Missing Miracle

Despite the mistaken belief that the LLD position magically improves outcomes, subjects die in this position every day. Christopher Lopez (Pueblo, Colorado prison) was restrained and then placed into the LLD position but died 30 minutes later, with no further use of force.

Figure 7. Christopher Lopez in LLD position 30 minutes before death.

Brief Summary of Opinions in This Case

1. Mr. Timpa was never exposed to weight force sufficient to compromise his breathing.
2. Early in the restraint process, 2:14 – 3:29 (min:sec), Mr. Timpa had a calculated weight force of about 175 lb on his back. This is below the 225 lb prone weight demonstrated to be safe even with hog-tied subjects.[114]
3. During this brief period of the maximum restraint, Mr. Timpa was still able to yell which demonstrates ventilation.
4. This brief period of strong restraint ended 11:12 (min:sec) before the Versed injection and thus did not cause a fatal asphyxia.

Timeline

Table 1. Restraint Timeline

Time	Dillard Knees on Back	Vasquez Knees on Back	Total Knees on Back	Total Weight Force	Notes
00:00.0	0	0	0	0.0	
01:29.0	0	0	0	0.0	
01:29.1	0	0.5	0.5	35.8	Vasquez knee mostly on L upper arm
01:30.2	0	0.5	0.5	35.8	
01:30.3	1	0.5	1.5	107.3	
01:39.6	1	0.5	1.5	107.3	
02:05.2	1	0.5	1.5	107.3	
02:05.3	1	1	2	143.0	Vasquez shifts knee over back
02:14.5	1	1	2	143.0	
02:14.6	2	1	3	175.2	Dillard places R knee
03:28.7	2	1	3	175.2	
03:28.8	1	1	2	143.0	Dillard removes 2nd knee
04:03.9	1	1	2	143.0	
04:04.0	1	0	1	71.5	Vasquez knee off
04:15.2	1	0	1	71.5	Clear shot showing only knee on back is Dillard's
14:29.2	1	0	1	71.5	
14:29.3	0	0	0	0.0	
14:32.9	0	0	0	0.0	
14:33.0	1	0	1	71.5	
14:41.0	1	0	1	71.5	Versed Injection
15:16.2	1	0	1	71.5	
15:16.3	0	0	0	0.0	
16:02.0	0	0	0	0.0	Placed on gurney

Times are from the merged video of Mr. Barry Dickey

Details of Opinions

The merged video of Mr. Barry Dickey was analyzed along with the deposition transcripts of Officers Dillard and Vasquez to produce the restraint timeline of Table 1. There is a brief period where Ofc. Vasquez has his knee split over Timpa's left upper arm and axillary region; I scored this as ½ knee.

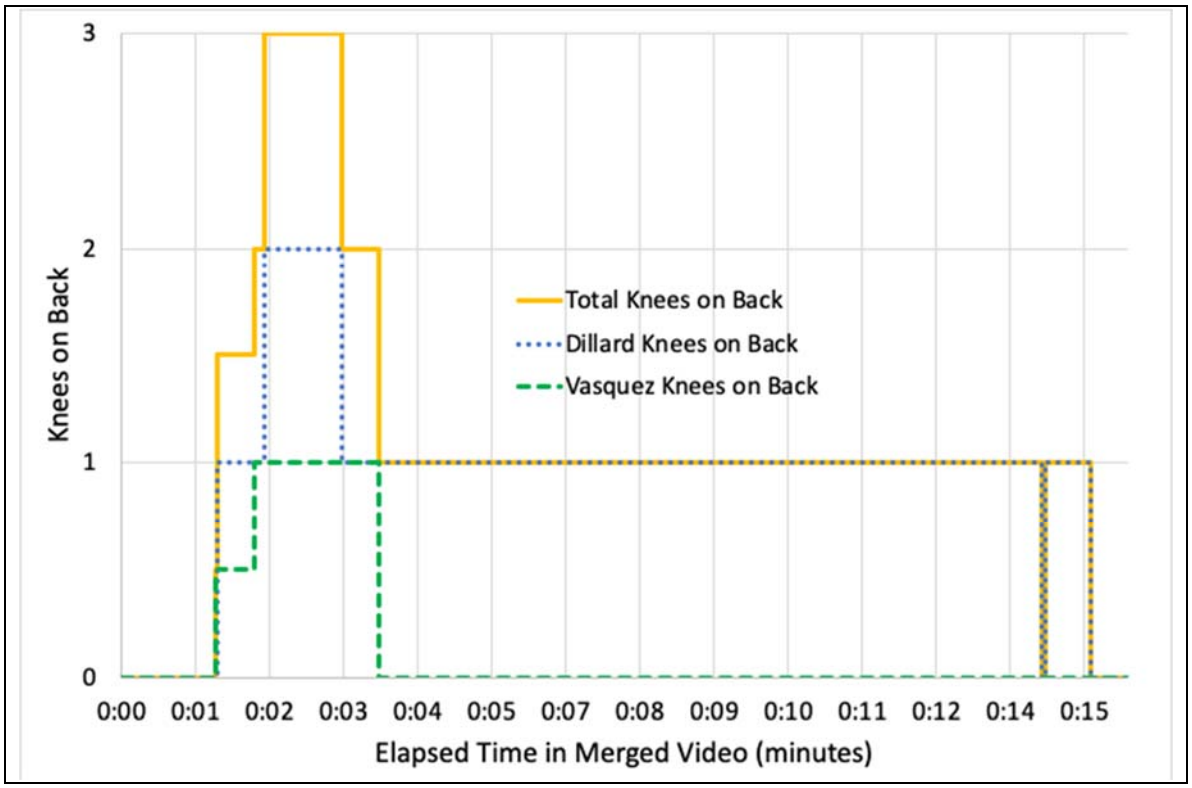


Figure 8. Knees on Mr. Timpa's back vs. time in merged video.

These data were then used to calculate the total weight force as shown in Figure 1. It is seen that the total weight force never exceeds the demonstrated safe weight of 225 lbs in even hog-tied subjects.[114]

I conservatively used the knee weight-force values for handcuffing. For this procedure, officers need to apply sufficient force to prevent push-ups and to control the free hands. That was not needed in this case as Mr. Timpa was already handcuffed and thus could not do push-ups. Since Mr. Timpa was already cuffed, there was no need to control his arms and Ofc. Dillard was able to use the strong leverage available at the shoulders to keep Mr. Timpa largely in control. Pushing down on the shoulders had the effect of reducing the downward force exerted by Ofc. Dillard's knees. Hence, the knee force values shown below should be considered very conservative and the actual values lower.

Officers Dillard and Vasquez weighed 160 and 190 lbs at the time of the incident respectively. I added 30 lbs for their vests and duty belt giving effective body weights of 190 and 220 lbs. This put them in the "Lower 3Q" (or normal body weight class of officers for purpose of calculating knee force.[139] The force from a single knee application is then given simply as 71 or 72 lbs so I used the average at 71.5 lbs. (I did not used the "Wisconsin" single knee technique as that would have given even lower values.)

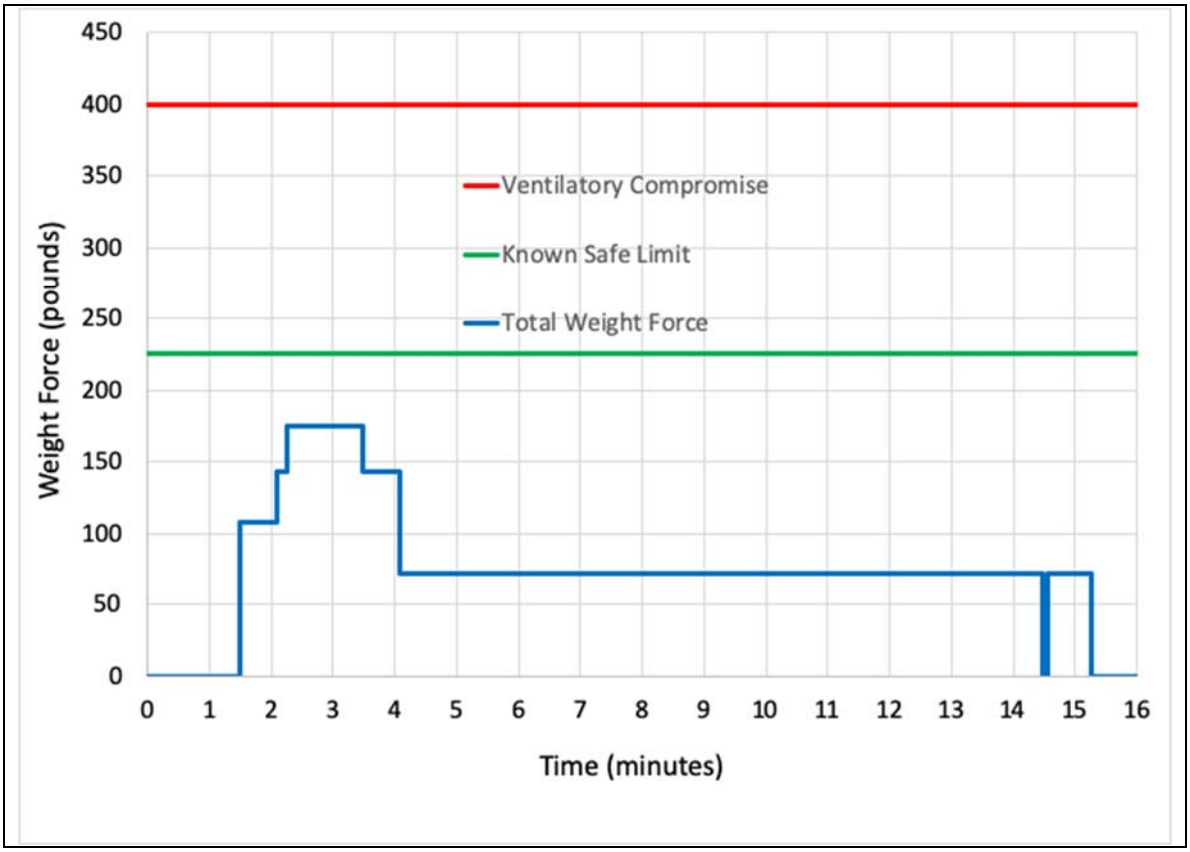


Figure 9. Calculated weight force vs. elapsed time in merged video.

Ofc. Dillard is 69.5 inches tall and that combined with his effective weight of 190 lbs gives him a BMI of 27.6 kg/m^2. For a male-officer double knee application, the total weight is given by 9.4 kg + 1.36BMI = 47 kg (103.7 lbs).[139]

These values were then used to produce the graph shown in Figure 9. The 225 lb known safe limit is taken from Michalewicz and the 400 lb ventilatory compromise value from crowd-crush research.[104,114,140,141]

It is clear that the officer restraint was never near a level of ventilatory compromise.

Materials Reviewed or Considered:

Photographs & Videos
- Body-worn cameras
- Autopsy photographs

EMS Run Sheet

Autopsy Report

Depositions
- Dr. Ogden
- Ofc. Dillard
- Ofc. Vasquez

General Comments

Previous Testimony

I have testified as an expert at trial or by deposition within the preceding 4 years in:

1. Excessive force case of Brossart v Nelson County, ND, US District Court, Fargo, ND. (Dec 2015)
2. Coroner's inquest in the death of Michael Langan. Provincial Court of Manitoba, Canada. (Jan 2016)
3. Criminal case of Illinois v. Brad McCaslin, Rockford, IL. Winnebago County State Court, IL. (May 2016).
4. Wrongful death case of Darden v Ft. Worth, TX. US District Court, Ft. Worth TX. (Jul 2016)
5. Criminal case of S. Carolina v Michael Slager. Charleston County State Court, SC. (Nov 2016)
6. Criminal case of Georgia v Eberhart & Weems. Fulton County State Court, GA. (Dec 2016)
7. Criminal case of Texas v Murray, Brazoria County State Court, TX. (Apr 2017)
8. Excessive force case of Khottavongsa v Brooklyn Center, MN . US District Court, St Paul, MN. (June 2017)
9. Electrical injury case of Rowan v Sunflower. US District Court, Kansas City, KS. (Sept 2017)
10. Electrical injury case of Garcia v Natchitoches, 10th Judicial District Court. Natchitoches City LA. (Sept 2017)
11. Patent Inter-Party Review of Nevro v Boston Scien., Wash. DC. US Patent Appeals Board. (Apr 2018)
12. Wrongful death case of Aguilar v Los Angeles PD. US District Court, Los Angeles, CA. (May 2018 and May 2019)
13. Wrongful death case of Ramos v East Hartford, CT. US District Court, Hartford, CT. (June 2018)
14. Wrongful death case of Todero v Greenwood, IN. US District Court, Indianapolis, IN (Sept 2018)
15. Wrongful death case of Silva (Haleck) v Honolulu, HI. US District Court, Honolulu. (May 2019)
16. Patent case of Cardionet v Infobionics. US District Court, Boston, Massachusetts. (Sept 2019)

Fees:

My fees for this expert consultant report are $480 per hour for the research and preparation, plus expense reimbursement. My fees for testimony (at trial or deposition) are $480 per hour plus anticipated expense reimbursement and are

due prior to the commencement of a deposition. Fees for travel are portal-to-portal and are $240 per hour when not performing work billable at $480 per hour.

Right To Amend:

The opinions in this report are living opinions. Should additional discovery material be received, or additional research be completed, and then reviewed, these opinions may be altered or reinforced depending upon what information is obtained, reviewed, or studied. If new issues are opined, identified, or developed subsequent to submission of this report, I reserve the right to supplement, or further supplement, this report. *I especially reserve the right to amend my report after receiving new forensic evidence.*

Further Development:

Further, the opinions, which are expressed in this report, are listed to comply with current report requests. Each opinion may be further developed through research, investigation, during deposition or trial testimony.

Specific References:

Some of the opinions in this report may list specific references to some of the case specific documents reviewed or considered. These listings are not intended to be all-inclusive. I specifically reserve the right to supplement the support for each of the opinions in this report.

Opinion Methodology:

The enclosed opinions were developed using the disciplines of bioelectricity, electrophysiology, biomedical science, cardiovascular physiology, scientific methods, mathematics, and physics and are to a reasonable degree of professional and scientific certainty.

Additionally, the opinions provided in this case were developed using one or more qualitative and quantitative research methodologies, in addition to my education, training, experience, and literature review.

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